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Simulation of SRM Drive Circuit - A Novel Approach

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ABSTRACT: An important factor in the selection of a motor and a drive for an industrial application is the cost. In the past decade, great emphasis has been put on coming up with reliable and cost-effective drives. The switched reluctance motor (SRM) is a simple, low-cost and robust motor and is therefore suitable for variable- speed and servo type applications. With relatively simple converter and control requirements, the SRM is gaining an increasing attention in the drive industry.

In spite of all the advances in switched reluctance motor, the evolution of the motor drive has not reached the stage where it can be feasible for high performance applications. High torque ripple during phase commutation, need for a good modeling method, reliable indirect position sensing and optimum converters are still issues of interest for the research in SRM drives. The performance of SRM drive can be improved by better motor design, efficient converter and an optimum control. This project has focused on the development of a high performance drive through improved converter and controller designs.

A new SRM converter topology modified from the conventional C-dump converter have been developed during the course of this research. This converter is referred to as Energy-efficient C-dump converter. The new converter topology eliminates most of the disadvantages of the C-dump converter without sacrificing its attractive features, and also provides some additional advantages. The attractive features of the proposed converter are: lower number of power devices, full regenerative capability, freewheeling in chopping, simple control strategy and faster demagnetization during commutation. Energy-efficient C-dump converter has only one-switch forward voltage drop, energy efficient converter has been simulated.

I. INTRODUCTION

Switched Reluctance Motor (SRM) exhibits desirable features including a simple construction, high reliability and low cost. However, the drive circuit is not necessarily suitable. Fig.1 shows the basic drive circuit for SRM. This is an asymmetry half bridge converter with 2 switching devices and 2 drive diodes per phase, and can't compose using a general 3-phase power module such as Intelligent Power Module (IPM). It is disadvantage for cost that SRM can't use the circuit similar to other ac motors. At the efficiency, this circuit is poor because of 2 device drops per phase. This circuit needs 2 wires per phase from the converter to the motor, which number is more than that of other motors, so they require more space and cost.[1]

In order to overcome their difficulty, various drive circuits for SRM are proposed. C-dump converter is one of them. But, it needs an external large inductor and a high voltage capacitor.[2]And, the additional circuit to maintain the capacitor voltage causes additional loss. In this paper, we propose a new drive circuit of SRM for advantages of cost, space, and efficiency, based on C-dump converter.

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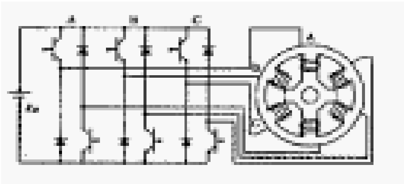


Fig.1 Basic drive circuit for SRM

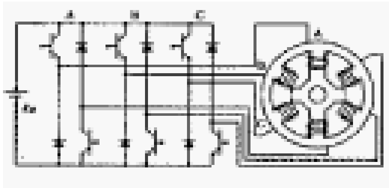
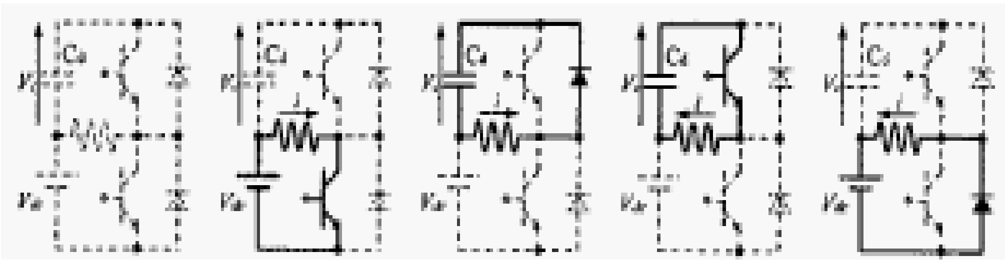


Fig.2 Proposed drive circuit for SRM.

II. OUR PROPOSAL CIRCUIT AND ITS OPERATION

Fig. 2 shows our new drive circuit for 3-phase SRM. This is similar to that of general 3-phase ac motors. So, it can be constructed using IPM at low cost, high efficiency, and compactness. This motor system needs I wire per phase and 1 common wire only. A capacitor and a dc voltage source are connected in series, and the common wire is connected to between the source and the capacitor. Fig. 3 shows the excitation mode of our proposal circuit.[3] First, the current doesn't flow and both devices are off (mode 0). If the capacitor voltage *Vc*, is lower than source voltage *Vdc* and the rotor position is suitable, turn on the low side device and the current flows from the voltage source to the device through the winding (mode I). After that, turn off the device at excitation end position, then the current commutates from the low side device to the high side diode and the capacitor is charged (mode 2). If V_C is higher than Vdc, turn on the high side device. Then, the capacitor is discharged and the current through the winding flows opposite to mode I (mode 3). Turn off the device, the current commutate from the high side to the lowside diode, and the energy is back to the source (mode 4). That means that *Vc* can be controlled as Vdc by choosing the high side device or the lowside device to excite the winding. The current direction is changed by the choice of switching device, but the torque of SRM is not affected.[4]

At the efficiency, this method has no additional loss for controlling *Vc*, and the device drops are only 1 per phase. At the device ratings, the voltage ratings of the devices are same *2Vdc* as that of C-dump converter, but the voltage rating of the capacitor is *Vdc* which is half of that of C-dump converter, so it makes the size of the capacitor small remarkably.[5]



Mode0 Mode1 Mode2 Mode3 Mode4

Fig. 3 Excitation mode of the proposed circuit.

III. SIMULATION

We simulated the proposed circuit using the general-purpose circuit simulator "SPICE".[6] The SRM model is based on magnetic circuit calculated using FEM [1]. The specification of SRM For examination is shown in Fig.4. The simulation conditions are *Vdc* as 60 V and load torque as 1.0Nm.[7-12]
The result is shown in Fig. *5*. When Vc is low, the phase current direction is plus. Or, the phase current direction is minus. Therefore, *Vc* is controlled surely.

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Material	35RM290
Stator Pole Arc βs	30deg.
Rotor Pole Arc βr	32deg.
Stack length	51mm
No.of windings/pole	72turns
Winding resistance/phase	0.87Ω

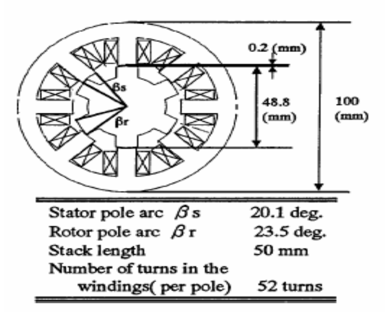

Fig. 4 Specification of SRM.

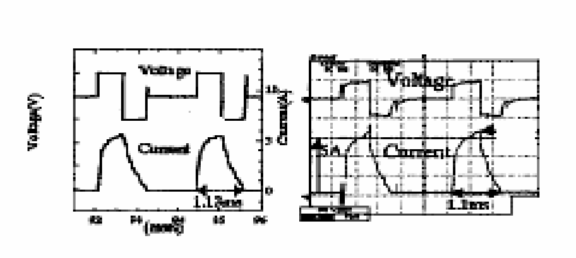

Fig.5.Simulation result

IV. CONCLUSION

We proposed a new drive circuit for SRM using general inverter. This circuit is high efficient, low cost, and compact.

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